THE JOURNAL OF
EDUCATIONAL PSYCHOLOGY

Volume 39 November, 1948 Number 7

THE OBLIQUE SOLUTION IN FACTOR ANALYSIS

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Clarification of terminology and notation is one rather pedestrian task that the student often must perform if he is to relate theories or formulations advanced by different workers in a field. Presumably, his attempt to relate formulations that either are or merely appear to be different represents a search for a greater understanding of the major ideas that have been advanced in a field of study. The exposition given here raises the question of similarities and differences in the oblique factor transformations given by the calculation procedures of Holzinger and of Thurstone in their texts.[1] It is hoped that this exposition will clarify what might appear to a casual reader to be basic discrepancies, and that this restatement will aid at least a few future students in their search for understandings in this area.

The problem can be posed specifically by taking Holzinger's example of an oblique transformation of centroids for eight physical variables, given in his Chapter XI.[2] The initial orthogonal solution and Holzinger's oblique solution are presented in Table 1. The centroid solution yields numerical values (columns 1 and 2) that give the correlation of each variable with each of the unrotated centroid reference axes. These numerical values also

[1] Karl J. Holzinger and Harry H. Harman, *Factor Analysis*. Chicago: University of Chicago Press, 1941.
L. L. Thurstone, *Multiple-Factor Analysis*. Chicago: University of Chicago Press, 1947.
[2] Pp. 234–48.

are the Cartesian coördinates that locate the variables in space with respect to the centroid reference axes. This is true because the reference axes are orthogonal. Consequently, the perpendicular projection of the variable on one axis (its correlation with that axis) locates a point that is identical in value with the point located by the projection of this variable, onto this axis, parallel to the second axis (one of its Cartesian coördinates). Since it establishes an orthogonal frame of reference, the centroid solution gives numerical values ('loadings') that represent both the structure and the pattern of the set of variables with respect to these axes. 'Structure' refers to the coefficients of correlation between the variable and the axes; 'pattern' refers to the coördinates of the variables in space with respect to the reference axes.

TABLE 1.—HOLZINGER OBLIQUE SOLUTION*

Variable (j)	Centroid Solution		Oblique Solution			
			Structure		Pattern	
	a_{jc_1}	b_{jc_2}	r_{jP_1}	r_{jP_2}	a_{jP_1}	b_{jP_2}
1	.83	−.40	.92	.48	.89	.05
2	.82	−.47	.94	.44	.96	−.03
3	.78	−.47	.91	.40	.93	−.05
4	.80	−.40	.89	.45	.88	.03
5	.79	.50	.46	.93	.00	.93
6	.67	.46	.37	.81	−.02	.82
7	.59	.44	.31	.74	−.06	.77
8	.65	.33	.41	.72	.08	.68

* Data taken from Karl J. Holzinger and Harry H. Harman, *Factor Analysis*. Chicago: University of Chicago Press, 1941, pp. 239, 245.

This distinction between structure and pattern is illustrated by Holzinger's data given in the remaining columns of Table 1. Holzinger calculates his oblique solution both in terms of the correlations of the variables with the new (oblique) reference axes, and in terms of the coördinates of the variables with respect to these new axes. He therefore presents two pairs of

columns of numerical values that are derived from the original pair of columns of values that were given by the centroid method. As will be pointed out later, the two oblique reference axes selected by Holzinger for this solution are positively correlated. The structure of his oblique solution therefore reveals fairly substantial positive correlations of each of the variables with each of the reference axes. Geometrically, this would be represented by two reference axes, separated by an acute angle, along or close to which lie the points representing the variables (points in N-space).[1] A variable that lies on one of these axes has, of course, a correlation with that axis. It also has a correlation with the second axis, since its perpendicular projection onto that second axis locates a point at some distance from the origin. Since, in this illustrative problem, the variables are all positive with respect to C_1 and the new reference axes are positively correlated, the structure values are positive, as would be expected.

The pattern values given in Table 1 include a number of entries that are essentially zero. These zero entries mean, geometrically, that variables 1 through 4 lie on or close to the first oblique reference axis, and that variables 5 through 8 lie on or close to the second oblique reference axis. Since they lie on one axis, their projections, taken parallel to that axis, intercept the second axis at or close to the origin, and give the resulting zero entries. The substantial positive loadings are interpreted in a similar fashion. Variables 1 through 4, for example, lie quite close to the first oblique reference axis. Their projections taken parallel to the second axis, onto this first axis, therefore should be similar in magnitude to their correlations with the first axis. The table shows that this is true. Further, any variable that lies exactly on one of the reference axes will have identical pattern and structure values with respect to that axis. This is true for variable 5, and the entries r_{5p_2} and b_{5p_2} in Table 1 consequently are identical.

As has been pointed out above, these pattern values constitute coördinates with respect to the oblique reference axes. They also are the coefficients in the linear equations describing the variables in terms of the factors. For variable 2, for example, the equation (ignoring uniqueness) would be written:

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[1] See Holzinger and Harman, *op. cit.*, p. 240, for the figure.

$$z_2 = .96P_1 + (-.03)P_2$$

where P_1 and P_2 are used to designate the oblique axes. The communality of the variable would be equal to the sum of the squares of these coefficients plus twice the cross-product of the coefficients weighted by the correlation between P_1 and P_2. The correlation between any two variables would (ideally) be reproduced by the paired products of the coefficients plus two additional values representing the non-paired products of the coefficients weighted by the correlation between P_1 and P_2. Thus for z_1 and z_2,

$$r_{z_1z_1} = (.89)(.96) + (.05)(-.03) + r_{P_1P_2}[(.89)(-.03) + (.96)(.05)]$$

Two wellknown points deserve emphasis here. One is that for an orthogonal, rather than an oblique, solution the correlation between factors is zero, and consequently these expressions simplify. For orthogonal solutions,

$$h_j^2 = a_j^2 + b_j^2 + c_j^2 + \cdots + m_j^2$$

where h_j^2 is the symbol for communality and a, b, . . . m represent the coefficients (pattern values) of the m common factors. Also,

$$r_{12} = a_1a_2 + b_1b_2 + c_1c_2 + \cdots + m_1m_2$$

where r_{12} is the correlation between variables 1 and 2, and a, b, ... m, the coefficients of the m common factors for the two variables, as before. The second point is that it is the pattern values, rather than the structure values, that are needed for these linear equations that describe the variables in terms of the postulated common factors.

A comment on the notation used in Table 1 is necessary. The symbols r_{jP_1} and r_{jP_2} are used for structure values. These indicate that the symbol P has been selected to designate Holzinger's oblique reference axes. Similarly, the coefficients are designated as a_{jP_1} and b_{jP_2}. These symbols, P_1 and P_2, imply that the Holzinger reference axes either are, or are analogous to, the familiar 'primary vectors.' Since primary reference axes are defined as axes formed by the intersections of planes or hyperplanes, it is clear that there can be no primaries, so defined, in a two-dimen-

sional system. These Holzinger reference axes are, however, a two-dimensional analogue of the primaries. The two-dimensional illustration will be discussed first, without further reference to primaries as such. Then a three-dimensional illustration will be taken and an attempt made to support this view.

THE TWO-DIMENSIONAL ILLUSTRATION

The demonstration to be made is that if we apply to the initial set of centroids, given in Table 1, Thurstone's procedure for making an oblique transformation, the resulting factor 'loadings' will not be identical with either the structure or the pattern values computed by Holzinger. This demonstration will set the problem. It will then be possible to develop geometrically the relationship between the Holzinger- and the Thurstone-type solutions for a two-dimensional problem. Later a three-dimensional illustrative problem will be used to generalize this relationship as one between a primary-axis solution and a simple-axis solution.

Thurstone's procedure for making an oblique rotation[1] follows this outline: First, the variables are plotted with respect to the centroid reference axes. This plot reveals two distinct clusters of variables, with 5 through 8 clustering in the first quadrant, and 1 through 4 clustering in the fourth quadrant. What will be called the *A*-plane[2] is passed through the origin and the cluster in the fourth quadrant. The *B*-plane is passed through the origin and the cluster in the first quadrant. Normals to these planes are erected, their direction numbers determined, and their direction cosines calculated. These direction cosines give a transformation matrix with which the original centroid matrix is post-multiplied to secure the rotated factor 'loadings.' This procedure applied to the original centroid matrix of Table 1 gives values that appear in the first two columns of Table 2. These columns have been labled 'structure values.' It may not be immediately obvious that these are, in fact, structure values; this point will be considered later. Also, in Table 2, V_1 and V_2 have been used as the symbols for the oblique reference axes, rather

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[1] Thurstone, *op. cit.*, pp. 194–205.

[2] For a two-dimensional problem, the term 'plane' is inappropriate, since it can have only one dimension. The term will be used here, however.

than *A* and *B*. The reason is that these numerical values represent projections on the normals to the *A*- and *B*-planes, rather than projections on the planes themselves. This distinction also will be discussed.

Table 2 also contains two columns headed 'pattern values.' These were computed from the structure values by the method described below. When we compare the structure and pattern

TABLE 2.—OBLIQUE SOLUTION BY THURSTONE'S METHOD

Variable (j)	Structure Values		Pattern Values	
	r_{jV_1}	r_{jV_2}	a_{jV_1}	b_{jV_2}
1	.04	.78	.56	1.06
2	−.03	.84	.50	1.08
3	−.05	.82	.46	1.04
4	.02	.77	.52	1.03
5	.81	.00	1.08	.55
6	.72	−.02	.94	.44
7	.67	−.05	.85	.36
8	.60	.07	.89	.48

values given in Table 2 with those given in Table 1, it is immediately apparent that we have a non-identity of numerical values for the two oblique solutions. This indicates, of course, that the oblique reference axes defined by the one procedure are not identical with those defined by the other procedure. The two procedures must be compared in order to define this difference explicitly. Comparison of Table 2 and Table 1 also suggests that the structure values of one solution are more similar to the pattern values than to the structure values of the other, and that the pattern values of one solution are more similar to the structure values than to the pattern values of the other. That a relationship between the two solutions might be found thus seems plausible.

That the Thurstone-type 'loadings' actually are structure values is easily demonstrated. For a two-dimensional problem, we have in general this relation:

$$\begin{vmatrix} r_{jV_1} & r_{jV_2} \end{vmatrix} = \begin{vmatrix} a_{jC_1} & b_{jC_2} \end{vmatrix} \cdot \begin{vmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \end{vmatrix},$$

in which the correlation of the variable, j, with each of the new reference axes, V_1 and V_2, is given by the indicated matrix multiplication of the coefficients of the orthogonal solution by the direction cosines for the new reference axes.[1] The operation involved in making the oblique rotation for the illustrative problem according to Thurstone's procedure is clearly this operation. The centroid coefficients were post-multiplied by a set of direction cosines. Consequently, the resulting values are structure values and have been so labeled in the first two columns of Table 2. These structure values represent the correlations of the variables with the new reference axes. These reference axes are, of course, the normals to the *A*- and *B*-planes, rather than the planes themselves. This is true because it was the direction numbers of the normals that were used in calculating the direction cosines.

The difference between the two sets of structure values given in Tables 1 and 2 reflects a difference in choice of reference axes. The Holzinger solution chooses as reference axes those running from the origin through the clusters of tests; the Thurstone-type solution chooses the perpendiculars to these as the reference axes. The reader may wish to determine direction numbers from the diagram given in Figure 1 and verify this for himself. The solid lines represent the reference axes chosen by Holzinger, and are labled P_1 and P_2. Thurstone's method regards these solid lines as the *A*- and *B*-planes, and determines direction numbers for their perpendiculars, which are represented by dashed lines. The resulting matrices of direction cosines are:

Holzinger		Thurstone-Type	
.880	.841	.466	.539
−.474	.541	.885	−.842

Lack of precise plotting introduces slight discrepancies; it is clear, however, that the column of one matrix defines a line that is perpendicular to the line defined by the corresponding column of the other. One matrix is the transpose of the normalized

[1] Holzinger and Harman, *op. cit.*, p. 244.

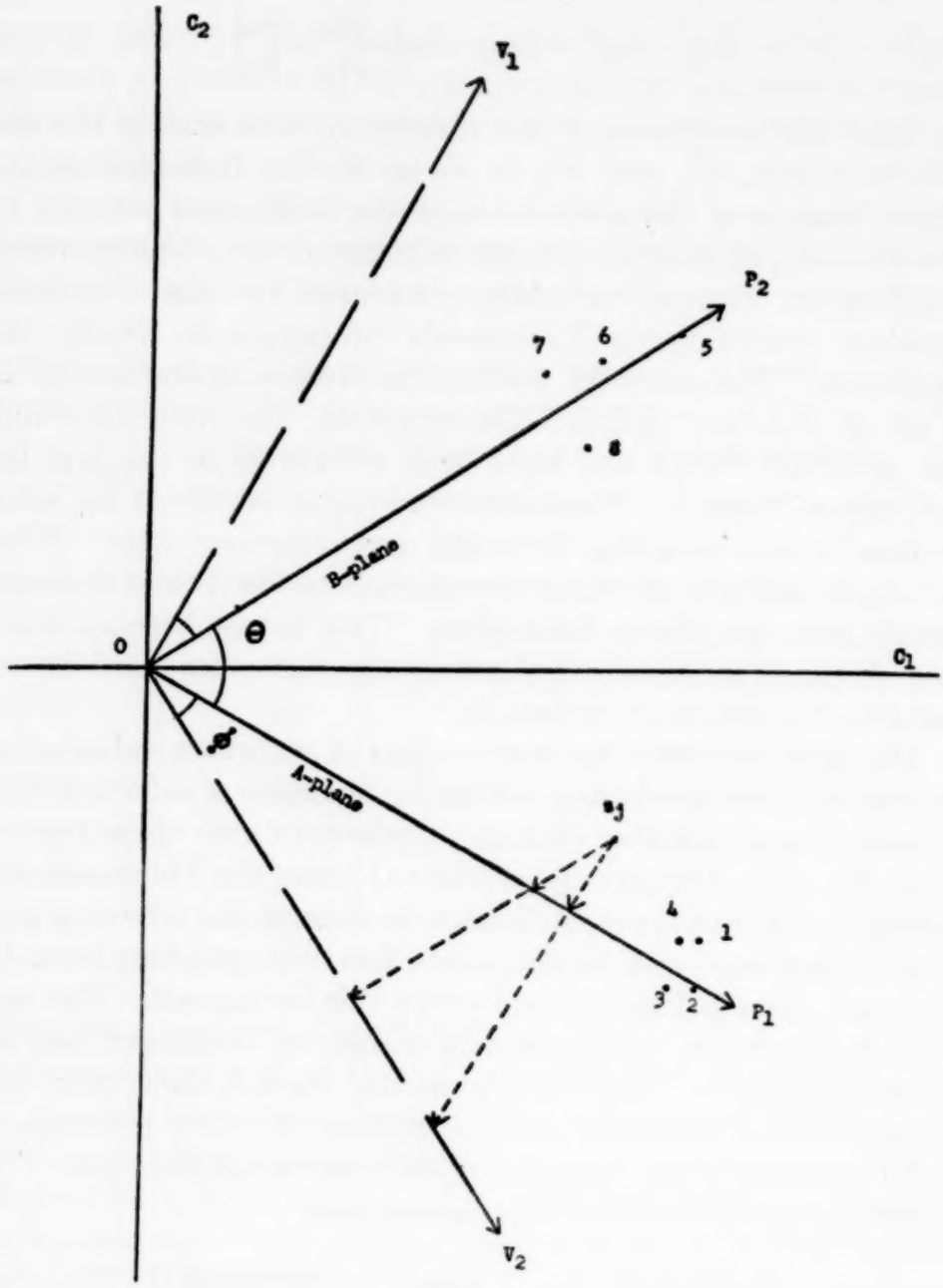

Fig. 1

inverse of the other. This will be shown below, in connection with the three-dimensional problem.

The correlation between any two reference axes in a Cartesian system is the scalar product of the paired direction cosines of these reference axes. This operation for the Holzinger matrix gives +.484, and for the Thurstone-type matrix, −.494. That these should be identical in absolute value (within rounding errors) can be seen by reference to Figure 1, where θ is the angle between Holzinger's reference axes, and θ plus ϕ equal a right angle. The correlation between the reference axes chosen by Holzinger (solid lines) equals:

$$\cos (90° - \phi) = + \cos \theta$$

For the reference axes perpendicular to the *A*- and *B*-planes, the correlation between axes equals:

$$\cos (90° + \phi) = - \sin \phi = - \cos \theta,$$

since sin ϕ equals cos θ. The reference axes chosen by Holzinger form an acute angle, and are positively correlated; those defined by the Thurstone procedure form an obtuse angle, and are negatively correlated to the same extent.

The relationship between a pattern and a structure is given by Holzinger,[1] and the calculation of pattern values from structure values is described in detail.[2] The pattern values given in the last columns of Table 2 were calculated from the structure values for the Thurstone-type solution. Some of these values, it will be noted, are greater than 1. These entries do not represent rounding or arithmetic errors, however, since pattern values are coördinates and may take values greater than 1. This would not be true for structure values, though, since they are correlation coefficients and are limited to the range ± 1.

Now let us examine the relationship between these two types of oblique solution in terms of the relationship between the pattern values of one solution and the structure values of the other. In Figure 1, a variable, z_j, is located with the coördinates (with respect to the centroid axes) of .70 and −.25; these values are, in other words, its coefficients with respect to the original

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[1] Holzinger and Harman, *op. cit.*, pp. 325–27.

[2] *Ibid.*, pp. 386–89.

orthogonal centroids. A perpendicular dropped from this point to the solid line that represents Holzinger's first oblique reference axis (P_1) determines Holzinger's structure value for this variable on this axis. It is, by calculation, .73; measurement from the origin to this point along this axis checks this result. Now if this line of projection is continued until it intercepts the dashed line labled V_2 (the Thurstone-type second oblique reference axis), it will determine the 'pattern' value for axis V_2 in the Thurstone-type solution. This is true because this line of projection is both perpendicular to Holzinger's first oblique reference axis and parallel to V_1, which is the first oblique reference axis in the Thurstone-type solution. Similarly defined projections of a second variable on these axes will then form a right-angled triangle that is similar to the one formed by the projections of the first variable. The triangles are similar since they have angle ϕ in common. A proportional relationship thus exists. A Holzinger structure value represents the base and the corresponding Thurstone-type pattern value the hypotenuse in each of a set of similar right-angled triangles that are defined by the projections of the variables. The reader will note that an interchange of columns is necessary for this proportionality to hold in the illustrative problem. The labeling of the reference axes, however, is arbitrary, and consequently this interchange of columns introduces no confusion.

It is also evident from Figure 1 that this proportionality holds for Thurstone-type structure values and Holzinger pattern values. A perpendicular has been dropped from z_j onto V_2; this intercept determines the structure value for axis V_2 in the Thurstone-type solution. This perpendicular also cuts the solid line P_1. Since this perpendicular is parallel to P_2, the point where it intercepts P_1 determines the pattern value for P_1 of this variable in the Holzinger solution. Here we have the relationship in which Thurstone-type structure values represent the bases and Holzinger pattern values represent the hypotenuses of similar right-angled triangles. Therefore, given one of these two oblique solutions, it is possible to calculate the other directly. For a two-dimensional system, we may write:

$$\text{Structure}_2 = (\text{Pattern}_1)(\sin\theta)$$

and

$$\text{Pattern}_2 = \frac{\text{Structure}_1}{\sin\theta} \qquad (1)$$

where the subscript 1 designates the given solution, and 2 the alternative one. This relationship could, of course, have been written in terms of the cosine of ϕ (the angle between P and V). In the three-dimensional problem it will be necessary to do so. Here it is convenient to write the relationship in terms of sine θ. It was pointed out above that the angle θ is known, no matter which solution is secured first. The equations in (1) thus present a feasible calculation procedure. Their significance, however, is that they define completely the relationship between values for these two types of oblique solution.

One further point regarding the two-dimensional problem is of interest. It will be recalled that the correlation between P_1 and P_2 (Holzinger reference axes) was computed as +.484, and the correlation between V_1 and V_2 as −.494. These are identical absolute values, within rounding errors. It was previously shown that they should be opposite in sign. The question of whether or not the correlation between the Holzinger reference axes can be reproduced from the Thurstone-type solution arises. This can be done by following Thurstone's procedure for transforming the correlation between his reference axes (V_1 and V_2) into what he calls the correlation between the primaries. When this calculation is made, the value for the correlation between primaries is given as +.486, which is identical with the value for the correlation between Holzinger's reference axes.

So far we have been concerned with pointing out that the calculation procedures for an oblique transformation or rotation of centroid axes that are given by Holzinger in Chapter XI of his text and by Thurstone in Chapter X of his text give non-identical solutions. Holzinger's method gives fairly substantial structure values for all variables, both for the two-dimensional problem used as an illustration in this paper and for the remaining numerical examples in his chapter. Thurstone's method gives structure values that include a number of zero entries in each column of the rotated matrix; this is true both for the illustrative problem displayed here and for the numerical examples cited in his chapter. This non-identity represents choice of two different sets of reference axes. Relationships between these two types of oblique solution for a two-dimensional problem have been pointed out. Relationships between corresponding matrices of direction cosines, correlations between reference axes, and the

values given by the two types of solution have been discussed. It has been shown explicitly that the pattern values of one solution are proportional to the structure values of the other, and equations for securing the values for one solution from those of

TABLE 3.—THREE-DIMENSIONAL ILLUSTRATIVE PROBLEM SIMPLE-AXIS SOLUTION*

Variable	Centroid Solution			Simple-Axis Solution					
				Structure			Pattern		
	a_{jc_1}	b_{jc_2}	c_{jc_3}	r_{jv_1}	r_{jv_2}	r_{jv_3}	a_{jv_1}	b_{jv_2}	c_{jv_3}
1	.31	−.12	.19	.3			.48	.18	.27
2	.31	−.12	.19	.3			.48	.18	.27
3	.42	−.16	.25	.4			.63	.24	.36
4	.52	−.20	.32	.5			.79	.30	.46
5	.56	.41	−.05		.6		.36	.78	.37
6	.65	.48	−.06		.7		.43	.91	.43
7	.47	.35	−.04		.5		.30	.65	.31
8	.65	.48	−.06		.7		.43	.91	.43
9	.21	−.11	−.11			.2	.18	.12	.32
10	.32	−.16	−.16			.3	.27	.18	.48
11	.42	−.21	−.21			.4	.36	.25	.64
12	.53	−.27	−.27			.5	.46	.31	.80

* Karl J. Holzinger and Harry H. Harman, "Relationships Between Factors Obtained from Certain Analyses." *Journal of Educational Psychology*, 28 (May, 1937), pp. 328, 329, and 341.

the other have been presented. It is now pertinent to turn to a three-dimensional illustration, for which the conventional definitions of a simple-axis and a primary-axis solution hold, and to show the relationship between these in similar terms.[1]

[1] For a method of obtaining an oblique solution in which the pattern coefficients for sections of the matrix of unit rank may be interpreted as structure values for the entire matrix, illustrated by this two-dimensional problem, cf. Karl J. Holzinger, "A Simple Method of Factor Analysis," *Psychometrika*, 9 (December, 1944), 257–262.

THE THREE-DIMENSIONAL ILLUSTRATION

In a three-dimensional system in which the test vectors form three distinct clusters it is possible to erect three planes, each one of which passes through the origin and two of the three clusters. The normals to these planes are then conventionally defined

TABLE 4.—THREE-DIMENSIONAL ILLUSTRATIVE PROBLEM PRIMARY-AXIS SOLUTION*

Variable	Primary-Axis Solution					
	Structure			Pattern		
	r_{jP_1}	r_{jP_2}	r_{jP_3}	a_{jP_1}	b_{jP_2}	c_{jP_3}
1	.38	.16	.23	.38	−.01	.01
2	.38	.16	.23	.38	−.01	.01
3	.51	.22	.31	.50	.00	.02
4	.64	.28	.38	.64	.00	.00
5	.30	.69	.31	.00	.69	.01
6	.35	.81	.36	.00	.81	.00
7	.25	.59	.26	−.01	.59	.00
8	.35	.81	.36	.00	.81	.00
9	.15	.11	.26	.00	.00	.26
10	.23	.17	.39	.00	.00	.39
11	.30	.23	.52	−.01	.00	.52
12	.38	.28	.66	−.01	−.01	.67

* Karl J. Holzinger and Harry H. Harman, "Relationships Between Factors Obtained from Certain Analyses" *Journal of Educational Psychology*, 28 (May, 1937), pp. 334, 342.

as the simple axes. The axes that are defined by the intersection of each pair of planes are called the primary axes. Holzinger has presented such an illustrative problem.[1] Tables 3 and 4 have been adapted from his data; Table 3 presents the simple-axis solution for the given centroids, and Table 4 the primary-axis

[1] Karl J. Holzinger and Harry H. Harman, "Relationships between Factors obtained from Certain Analyses." *Journal of Educational Psychology*, 28 (May, 1937), 321–345.

solution. This problem was used by Holzinger to illustrate the two types of solution. Our purpose is to employ Thurstone's extended vector representation[1] for deriving both the simple-axis and the primary-axis solutions to this problem.

Holzinger's procedure for securing the simple-axis solution is to write the equations for the three planes, each of which passes through the origin and two of the clusters. These equations are written with coefficients given by their normalized coördinates with respect to the centroid axes. (These normalized coördinates also are the direction cosines of the axes joining the origin and the points taken to define the clusters.) These equations are then solved for the values of the direction cosines of the normals, and these direction cosines used as the transformation matrix for securing the simple-axis structure values. Pattern values may be calculated from the structure values by the procedure referred to above. Thurstone's extended vector representation demands one plot for this three-dimensional problem. This is given in Figure 2. The orthogonal axes appearing in this figure are labeled C_2 and C_3; the variables have been located with respect to these axes, their coördinates being the extended vector values for C_2 and C_3. This figure represents in a plane all the variables extended so that their correlation with C_1 is unity; consequently the first coördinate for each variable (a_{jc_1}) is unity. Thurstone's procedure is to locate the *A*-, *B*-, and *C*-planes. These are represented by the solid lines joining the three clusters of variables. Normals to these planes, passing through the intersection of C_2 and C_3, are then drawn (dashed lines) and their direction numbers determined. The direction cosines of the normals are then calculated from these direction numbers, and the matrix of direction cosines used as the transformation matrix for the oblique solution. When this procedure is applied for the illustrative problem, the calculated values are identical with the simple-axis structure values obtained by Holzinger's method that are given in Table 3.

Holzinger also has calculated a primary-axis solution, given in Table 4. The primaries are defined as the axes formed by the intersections of the planes referred to above. The direction cosines of these axes therefore may be determined from the

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[1] Thurstone, *op. cit.*, Chapter XI.

equations of the planes. Holzinger used this method in securing his solution. It also should be noted that the normalized coördinates with respect to the centroid axes of the points representing the three clusters give these direction cosines directly. This will

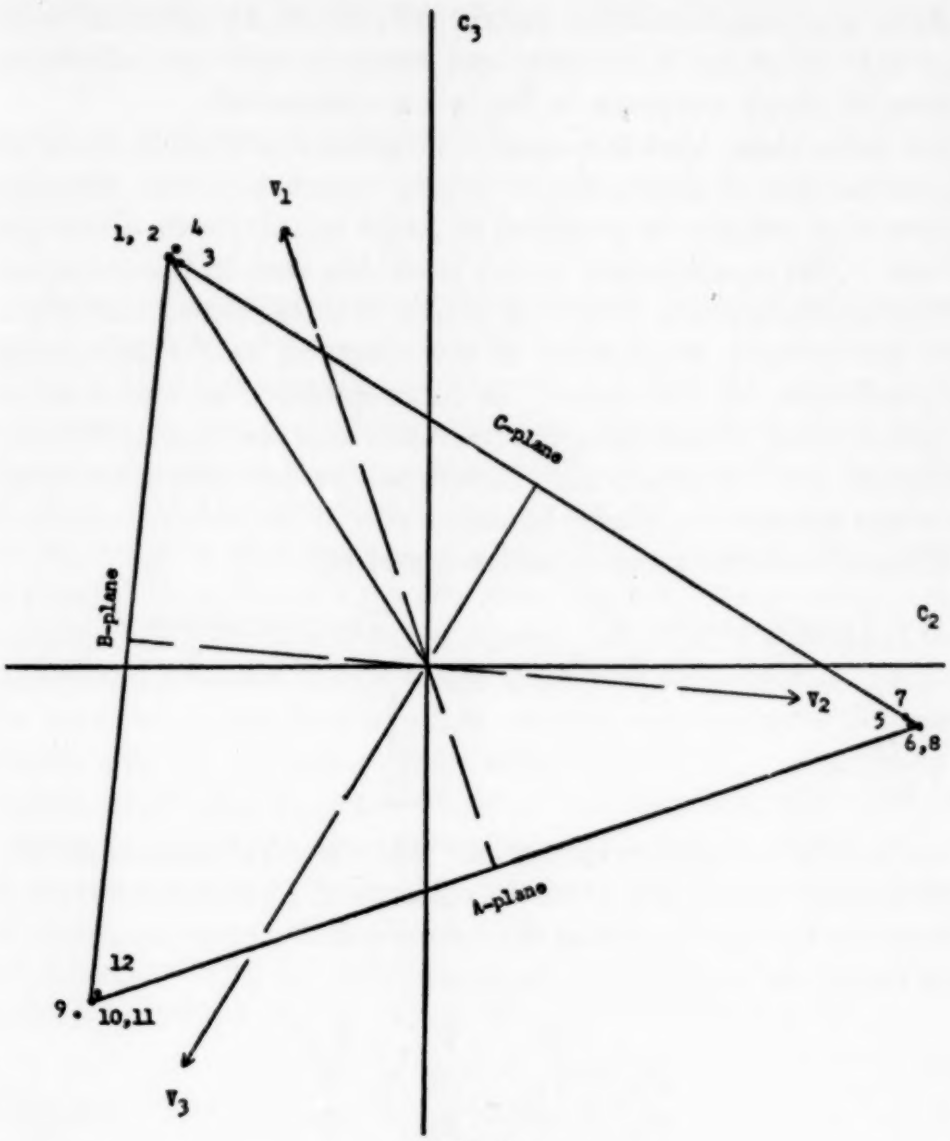

Fig. 2

be illustrated from Figure 2. In this planar representation, the primaries should be represented by lines joining the origin and each of the three clusters. One such line has been drawn, joining the origin and the cluster defined by variables 1,2,3, and 4. The direction numbers of these lines, in the extended vector system, are the coördinates of the points taken to represent the

clusters. For this cluster they are, approximately, C_1, 1.00; C_2, −.39; and C_3, +.61. Normalizing these direction numbers gives the direction cosines of the primary axis that is determined by the intersection of planes *B* and *C*. Direction cosines for the remaining two primary axes would be computed similarly. When this is done, the transformation matrix is found to be identical with that calculated by Holzinger, and consequently the solutions, values for which are given in Table 4, are identical.

We note, then, that the regular Thurstone procedure leads to the calculation of simple-axis structure values, but that this procedure may readily be modified to yield primary-axis structure values. The modification, which is readily seen in the extended vector representation, is that of choice of lines joining the origin and the clusters or 'corners' of the diagram, rather than lines perpendicular to the planes, as representative of the oblique reference axes. Since different reference axes are chosen, the two solutions are not identical. Relationships between these non-identical solutions will now be reviewed.

Take as the two transformation matrices:

Transformation T'

	P_1	P_2	P_3
I			
II			
III			

Transformation Λ

	V_1	V_2	V_3
I			
II			
III			

with direction cosines as elements. The direction cosines for the primary axes would appear in the columns of T', and the direction cosines for the simple axes in the columns of Λ. Post-multiply T (the transpose of T') by Λ to secure:

	V_1	V_2	V_3
P_1	r_{11}	0	0
P_2	0	r_{22}	0
P_3	0	0	r_{33}

in which the correlations between corresponding primary and simple axes are given by the diagonal elements. This operation, in effect, treats the direction cosines of the primary axes as coefficients in the orthogonal centroid matrix and transforms them into structure values (correlations) with respect to the oblique simple axes. Further, this matrix will be a diagonal matrix, since

each simple axis will, by definition, be orthogonal to all except one of the primaries. A primary axis that is defined by the intersection of two planes is uncorrelated with the perpendiculars to those planes.

This diagonal matrix giving the correlation of simple and primary axes may be designated D. Then:

$$T\Lambda = D \tag{2}$$

$$T = D\Lambda^{-1} \tag{3}$$

$$T' = (D\Lambda^{-1})' \tag{4}$$

Similarly,
$$\Lambda = T^{-1}D \tag{5}$$

and
$$\Lambda' = (T^{-1}D)' \tag{6}$$

In the two-dimensional problem it was noted that the two transformation matrices are related; one matrix is the transpose of the normalized inverse of the other. The reader no doubt will recognize that in these equations the multiplication by D represents only the operation of normalizing either the rows or the columns, depending upon whether it is a pre- or a post-multiplication by D, of the corresponding inverse. Thus we may state in general that, for the simple- and primary-axis solutions, the transformation matrix of one is equivalent to the transpose of the normalized inverse of the other transformation matrix. Since the transformation matrices are related, the matrices of intercorrelations of reference axes also are related. Thurstone's recommended procedures include the calculation of the intercorrelations of the primary axes from the data of the intercorrelations of the simple axes; thus, he makes explicit this relationship.[1] In the matrix notation used above, the intercorrelations of the primaries may be designated TT', and the intercorrelations of the simple axes, $\Lambda'\Lambda$. Thus, from (3) and (4), above:

$$TT' = (D\Lambda^{-1})(D\Lambda^{-1})' \tag{7}$$

Similarly,
$$\Lambda'\Lambda = (T^{-1}D)'(T^{-1}D) \tag{8}$$

Thus the intercorrelations of either set of reference axes may be computed from the data provided by the alternate solution.

Finally, the relationship between the numerical values yielded by the two solutions should be pointed out. The proportional relation between the structure values of one solution and the

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[1] Thurstone, *op. cit.*, pp. 137–38.

pattern values of the other holds for the three-dimensional problem, as it did for the simpler illustration. (Compare Tables 3 and 4.) In the two-dimensional problem, the constant of proportionality was seen to be the cosine of the angle ϕ (Figure 1.) In other words, the correlation between the related simple and primary axes gives this constant of proportionality. For the three-dimensional problem, these constants, which are given by the elements of the diagonal matrix D, are respectively, .78, .86, and .78. Thus the structure values in column r_{jV_2} of Table 3 are equivalent to the pattern values in column b_{jP_2} of Table 4, multiplied by .86. In general terms,

$$\text{Structure}_2 = (\text{Pattern}_1)K \qquad (9)$$
$$\text{Pattern}_2 = \frac{\text{Structure}_1}{K}$$

where 1 and 2 refer to the two types of solutions, and K, the constant of proportionality, is the correlation between related (i.e., not uncorrelated) axes of the two solutions. Again, it should be noted that equations (9) give a feasible calculation procedure for securing the values of one solution from those of the other, since the needed values of K are given by the elements of D, which can be calculated from either transformation matrix.

CONCLUSION

The major purpose of this paper has been to present in some detail certain relationships between two types of oblique-factor solution—the simple-axis and the primary-axis solutions. It was first pointed out that the procedures for securing an oblique solution that are given and illustrated in Chapter XI of Holzinger's text and in Chapter X of Thurstone's text lead to non-identical values. Such a fact indicates that the preferred oblique solution differs from one author to the other. This difference was identified as the choice, respectively, of the primary-axis and the simple-axis solution. The relationships between these two types of solution were illustrated by means of a two-dimensional and a three-dimensional problem. The relationships were specified with respect to the transformation matrices, the intercorrelations of the reference axes, and the numerical values yielded by the solutions. It was shown that given one of these two solutions, the other could be readily secured either by writing a new trans-

formation matrix in terms of the given one, or by writing the new structure and pattern values in terms of the given ones.

It is hoped that this emphasis on relationships between the primary-axis and the simple-axis solutions may have some pedagogical value for students. What appears to be a more practical outcome, however, has been the development of a rotation method on the basis of these relationships. This method will be described and its use illustrated in a forthcoming article in this JOURNAL. Briefly, the method provides for the identification of the primary axes from the extended vector diagrams (as was illustrated above for the three-dimensional problem) and the direct rotation to primary structure. Application of the method to several problems indicates that it gives precise solutions, that it is objective, that it is general rather than being restricted to certain kinds of problems, and that it is economical. The economy of the method, which substitutes one rotation for the customary several sets of rotations in complex problems, should recommend it for consideration by students.

STUDENT PROBLEMS IN A TEACHERS COLLEGE

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Students, even those who seem intellectually apathetic, all have problems for which they seek immediate solutions and about which they would welcome guidance. But students are often on the defensive and will therefore 'cover up' about these problems. The task becomes, then, one of bringing to light concealed problems—problems that frustrate, that thwart adjustment, that interfere with efficient study, etc. It may be that in many cases students do not even recognize their real underlying conflicts. Students will reveal, however, rather obviously the symptoms of their conflicts which in turn may be analyzed for purposes of discovering major problems. These symptoms, if not the conflicts themselves, may be found in answers which students give to carefully stated questions and problems. At River Falls State Teachers College the Mooney *Problem Check List*[1] (College Form) was selected as one means of uncovering student problems. It was thought that the results would sensitize the faculty to the range and importance of student needs through the students' own written reactions. The problems and questions which college students recognize as being of importance to themselves and for which they feel the need of immediate answers should be among the principle criteria used by a college faculty in the construction of a functional curriculum. These felt needs are probably as important as criteria of guidance in curriculum construction as are criteria drawn from logical organization of subject-matter.

In March, 1947, the Mooney *Problem Check List* was administered to five hundred seventy-eight students at the River Falls State Teachers College. This group was composed of forty-two seniors, fifty-eight juniors, one hundred twenty-six sophomores, and three hundred fifty-two freshmen.

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[1] Ross L. Mooney, *Problem Check List.* (College Form) Columbus, Ohio: Bureau of Educational Research, Ohio State University, 1941.

THE CHECK LIST

This instrument consists of a list of three hundred thirty troublesome problems which often face students in college. At the end of the list are five summarizing questions.

Directions for filling out the check list consist of three steps. The students are instructed to: (1) Read the list slowly, pause at each item, and if it suggests something which is troubling you, underline it. (2) After completing the first step, look back over the items you have underlined and circle the numbers in front of the items which are of most concern to you. (3) After completing the first and second steps, answer the summarizing questions. The three hundred thirty problems are classified in eleven areas or categories. There are thirty problems in each category. The eleven categories are listed in Table 1.

TABLE 1.—RANK ORDER OF ELEVEN CATEGORIES OF PROBLEMS

Categories		Rank order of underlined problems	Rank order of circled (serious) problems
ACW	Adjustment to College Work	1	1
SRA	Social and Recreational Activities	2	6
CTP	Curriculum and Teaching Procedures	3	5
PPR	Personal-Psychological Relations	4	3
FVE	The Future: Vocational and Educational	5	2
FLE	Finances, Living Conditions, and Employment	6	4
HPD	Health and Physical Development	7	7
SPR	Social-Psychological Relations	8	9
CSM	Courtship, Sex and Marriage	9	8
MR	Morals and Religion	10	11
HF	Home and Family	11	10

PURPOSE AND PROCEDURE IN ADMINISTERING THE CHECK LIST

The purpose of administering the *Problem Check List* was to discover specific problems, curricular and extra-curricular, which

are factors in students' adjustment and accomplishment in college. It was thought that the results might be of value in considering how well the college was fulfilling some of its responsibilities, such as personal adjustment, social adjustment, counseling and teaching procedures, etc., which were rated as important by the faculty and students on a previous questionnaire.

This was a 'group' study. There was no attempt to learn about the problems of any specific student. However, individual patterns of problems were studied. Students were asked not to sign their names to the check list. It was felt that if they signed their names the validity of the results would suffer, because (1) some students might be induced to check items because they think they are expected to have problems—thus showing a willingness to coöperate, (2) some students might refuse to designate problems of real concern because they have become over-sensitive and on the defensive concerning them.

The stand taken on this was probably justified in light of comments which a number of students volunteered to the third question about the check list. The question was: "Whether you have or have not enjoyed filling out the list, do you think it has been worth while doing? Could you explain your reaction?" Illustrative of the comments made by students are the following—

"Yes, I have had a chance to say many things that have been bothering me but which one wouldn't ordinarily say even to a best friend."

"This gave me a chance to check problems and make suggestions for improvements in our school which otherwise may prove embarrassing."

"Since I am not required to sign this I feel I can be frank in what I say."

"I don't know how much good this will do, as I am not signing my name, but I got some things off my chest anyway that I wouldn't have if I had signed it."

"I don't think my problems are anyone else's business but since this is not signed I guess it's O.K.—I feel unburdened."

SUMMARY AND DISCUSSION OF FINDINGS

Table 1 lists both the underlined problems and the serious problems in rank order by categories or problem areas. It is interesting to observe that there are several differences in the rank

order of problem areas. The problems classified as 'Adjustment to College Work' are ranked first both as underlined problems and serious problems, while problems of 'Social and Recreational Activities' rank second among the underlined problems but sixth among the serious problems. Problems involving the 'Future: Vocational and Educational' are ranked second in importance among the serious problems but sixth among the underlined problems. The results of the data in Table 1 raise the question of the relative importance of the underlined problems and the circled (serious) problems. In a study of college upper-class students (juniors and seniors) by Hibler and Larsen[2] they stated: "The underlined items in general tend to be irritations more than major problems. . . . The circled items . . . have proved the more diagnostic of the two, both in the screening process and as indicating the areas in which major conflicts lie."

The total number of underlined problems outnumbered the total number of circled problems by a ratio of approximately five to one. The mean number of items underlined by five hundred seventy-eight students was 27.1 per individual. The mean number circled was 5.8 per individual. In Table 2 it can be seen that the lower-classmen as a group were more problem-conscious than the upper-classmen, both as regards underlined problems and serious problems.

TABLE 2.—MEAN NUMBER OF ITEMS CHECKED PER STUDENT

Classes	Underlined items	Circled items
Freshmen	28.2	6.3
Sophomores	32.2	7.3
Juniors	17.9	3.8
Seniors	25.1	5.8

Table 3 lists the problems by categories that were underlined by fifteen per cent or more of the students in any one class-year group. Under each class, the two columns give, first, the percentage of students in that class who designated this problem as

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[2] Hibler, Francis W., and Larsen, Arthur Hoff. "Problems of Upperclass Students in a Teachers College." *Journal of Applied Psychology*, Vol. 28, No. 3, June 1944, p. 253. The authors used the Mooney *Problem Check List* in this study and individual students were each identified by name and a clinical procedure was employed.

TABLE 3.—ITEMS MOST FREQUENTLY UNDERLINED BY EACH CLASS

Category	Problem Description	Freshmen Per Cent	Freshmen Rank	Sophomores Per Cent	Sophomores Rank	Juniors Per Cent	Juniors Rank	Seniors Per Cent	Seniors Rank
ACW	Don't know how to study effectively	46	1	41	3	26	5	—	—
	Unable to concentrate well	42	2	42	2	19	17	19	—
	Unable to express myself in words	34	3	37	7	22	11	—	—
	Vocabulary too limited	32	7	35	8	22	11	33	3
	Slow in mathematics	30	9	34	9	15	—	—	—
	Afraid to speak up in class discussion	30	10	—	—	—	—	—	—
	Weak in spelling or grammar	30	11	26	—	22	12	21	20
	Worrying about examinations	28	15	39	4	26	6	19	—
	Purpose in going to college not clear	25	20	—	—	—	—	—	—
	Getting low grades	23	—	25	—	—	—	—	—
	Fearing failure in college	21	—	—	—	—	—	—	—
	Poor memory	21	—	30	12	19	17	15	—
	Slow in reading	21	—	—	—	15	—	—	—
FVE	Restless at delay in starting life work	35	4	38	6	36	1	33	3
	Wondering if I'll be successful in life	32	5	27	19	24	7	29	8
	Not knowing what I really want	32	6	31	10	—	—	17	—
	Doubting wisdom of my vocational choice	27	16	27	18	—	—	33	3
	Needing to know my vocational abilities	23	—	25	—	17	20	17	—
	Needing to decide on an occupation	22	—	—	—	—	—	—	—
	Wanting advice on next steps after college	—	—	—	—	—	—	21	20

CTP	Inadequate high-school training	30	8	27	18	—	—	—	—
	Dull classes	29	12	42	1	19	17	31	5
	Hard to study in living quarters	20	—	—	—	20	14	29	8
	Too much work required in some courses	—	—	29	15	—	—	23	14
	Grades unfair as test of ability	18	—	30	11	17	20	31	6
	Forced to take courses I don't like	—	—	26	—	—	—	26	10
	Wanting courses not offered by school	—	—	24	—	17	20	23	12
	Teachers too theoretical	—	—	—	—	—	—	21	19
PPR	Day-dreaming	29	13	29	13	15	—	—	—
	Afraid of making mistakes	28	14	25	—	28	4	17	—
	Lacking self-confidence	26	17	27	20	22	11	26	9
	Nervousness	24	—	39	5	21	14	36	1
	Taking things too seriously	19	—	23	—	—	—	21	16
	Worrying about unimportant things	17	—	—	—	22	8	21	18
	Forgetting things	—	—	—	—	—	—	21	18
SRA	Too little chance to read what I like	26	18	28	15	29	2	24	13
	Wanting to learn how to dance	23	—	—	—	—	—	—	—
	Boring weekends	23	—	—	—	16	—	15	—
	Being ill at ease at social affairs	22	—	—	—	—	—	—	—
	Unskilled in conversation	21	—	—	—	15	—	—	—
	Too little chance to enjoy music and art	—	—	25	—	15	—	—	—
	Not enough time for recreation	—	—	23	—	28	3	29	8
	Lacking a place to entertain friends	—	—	—	—	21	14	22	15

important to them; and, second, the order in which the twenty most frequently mentioned problems were checked by members of that class.

The items in Table 3 are grouped according to the 'categories' in the *Check List*. The problems which students checked most frequently seem to fall into five groupings. Therefore Table 3 deals with only these five area groupings:

ACW—Adjustment to College Work.
FVE—The Future: Vocational and Educational
CTP—Curriculum and Teaching Procedures
PPR—Personal-Psychological Relations
SRA—Social and Recreational Activities

The question arising here is—To what extent is it the responsibility of the college to aid students in the solution of these problems? If the college accepts this responsibility, what procedures will be most helpful toward this end? Since so many of these problems are found to lie in the area of the personnel services rather than the academic a brief discussion of a concept of personnel work and procedures might be in keeping here.

Personnel work and counseling represents an organized effort on the part of the college equipped with both a knowledge of the student and information as to opportunities of an educational, a social, an emotional, and a vocational nature, to aid the individual student to adjust to his present situation in such a way as to provide the greatest development for him and to aid him in planning for his future. It has become an increasingly efficient means of recognizing the individual differences of all students and adopting educational purposes and procedures to fit their individual needs. Personnel work is based on faith in the improvability of people as opposed to the belief that human attitudes and character are inherited and unchangeable. Personnel work attempts to modify the attitude of the individual to the end that he has clearer insight into his own problems and a greater ability to integrate his own personality. The personnel services represent an organized effort to aid the development of students in the several phases of personality development. This development is neglected, too largely, when the college curriculum is confined to the traditional organization of academic subject-matter areas. One educator has stated that the steadily increas-

ing interest in the individual and his adjustment is perhaps one of the outstanding phenomena of our times and a basic concept involves the significance of the individual and his right to the elements of a satisfying adjustment.

Looking again at Table 3 dealing with the most frequently underlined items, it may be seen that most of these items fall into the area of college life which we designate as 'student personnel.' Evidence of this is found in the most frequently mentioned problem in each successive class year as follows:
Freshmen—46 per cent—"Don't know how to study effectively"
Sophomores—42 per cent—"Dull classes"
Juniors—36 per cent—"Restless at delay in starting life work"
Seniors—36 per cent—"Nervousness"
The 'dull classes' problem is the only one that does not fall definitely into the area of student personnel.

TABLE 4.—RANK ORDER OF SIX PROBLEM AREAS BY CLASSES
(Serious Problems)

Problem Areas	Freshman	Sophomore	Junior	Senior
ACW	1	1	1	5
SRA	5	6	6	2
CTP	6	4	5	4
PPR	3	3	2	3
FVE	2	2	3	1
FLE	4	5	4	6

A tabulation of all serious problems into their respective category areas shows that freshmen, sophomores and juniors expressed serious concern regarding a greater number of items in the ACW—Adjustment to College Work—than in any other. This is revealed by Table 4. It was to be expected among freshmen, but to have the same problems persist through the sophomore and junior years as 'most important' would seem to indicate a need for careful analysis of the present curricular and extra-curricular services of the college. It is possible that veterans entering at the sophomore and junior levels have effected this some.

Table 5 is based on student answers to the five questions at the end of the questionnaire. In this table we find that eighty-eight per cent of the students felt that the items they marked on the

list gave a well-rounded picture of their problems. To Question 2: "Have you enjoyed filling out the list?", eighty per cent answered 'yes,' while seventy-nine per cent (Question 3) thought it had been worth while regardless of whether or not they enjoyed filling out the list. Only sixty-six per cent thought they would like to talk over some of these problems with someone on the

TABLE 5.—'YES' AND 'NO' ANSWERS TO QUESTIONS ABOUT THE PROBLEM CHECK LIST

Questions	Answer	Number of students answering	Per cent of students answering
(1) Do you feel that the items you have marked give a well-rounded picture of your problems?	Yes	511	88
	No	33	6
	Blank	34	6
(2) Have you enjoyed filling out the list?	Yes	463	80
	No	80	14
	Blank	35	6
(3) Whether you have or have not enjoyed filling out the list do you think it has been worth while doing?	Yes	458	79
	No	56	10
	Blank	64	11
(4) If the opportunity were offered, would you like to talk over any of these problems with someone on the college staff?	Yes	381	66
	No	180	31
	Blank	17	3
(5) If so, do you know the particular person(s) with whom you would like to have these talks?	Yes	170	29
	No	208	36
	Blank	200	35

college staff and only twenty-nine per cent knew the particular person with whom they would like to have these talks.

The answers to Questions 4 and 5 have been analyzed further in Table 6 and Table 7. Table 6 indicates that only sixty-two per cent of the freshmen cared to talk over any of their problems with someone on the college staff. It is interesting to note that this was their attitude during the seventh month of their attendance in college. Eighty-one per cent of the seniors answered 'yes' to this question, which indicates that after four years in college there

were still nineteen per cent who were opposed to the idea of talking to any college staff member about any of their problems. This may indicate that many students do not think about college instructors as personnel workers, but rather as academic people who are impersonal in their behavior. Perhaps this implies that college instructors need to make a greater effort to become

TABLE 6.—PER CENT OF EACH CLASS ANSWERING 'YES' TO QUESTION 4—"If the opportunity were offered, would you like to talk over any of these problems with someone on the college staff?"

Class	Per cent Answering 'yes'
Seniors	81
Juniors	78
Sophomores	66
Freshmen	62

'human' and 'approachable.' There is need of building confidence more quickly, especially with freshmen.

Table 7 shows the per cent answering 'yes' for each of the four classes. Here we find that only twenty-five per cent of the freshmen knew of a staff member with whom they would care to talk over any of their problems. There is an improvement in this

TABLE 7.—PER CENT OF EACH CLASS ANSWERING 'YES' TO QUESTION 5—"If so, do you know the particular person(s) with whom you would like to have these talks?"

Class	Per cent Answering 'yes'
Seniors	53
Juniors	40
Sophomores	29
Freshmen	25

figure for each successive year level, until by the senior year fifty-three per cent answered 'yes.' The picture presented as a result of student answers to this question is a gloomy and negative one. The freshmen seem not to get to know and to meet instructors very soon. It would be safe to say that their confidence in seeking help varies inversely with the need. The

implication here seems to be clear—a need for a functional plan for faculty counseling and improved and effective personnel services in general.

GROUP DIFFERENCES

An attempt was made to find whether or not group differences existed in the results of the Mooney *Problem Check List.* The data were tabulated for sex, marital status, and veteran-civilian status.

Sex Differences

According to the questionnaire, it was found that men and women students reacted differently to many problems. First, it was interesting to learn that women listed a far greater number of problems than did men. Out of the three hundred thirty problems mentioned on the questionnaire women showed concern for approximately twice as many problems as men. The only category in which men showed more concern was the one involving finances. Women are more concerned about problems that involve health, living conditions, employment conditions, social and recreational activities, psychological and personal relations, home and family, adjustment to college work and teaching procedures. The problems in which the women show far greater concern are in the categories of morals, religion, courtship, sex, and marriage.

Veteran-Civilian

Forty-five per cent of the veterans and twenty-two per cent of the civilians checked "Restless at delay in starting life work."

Six per cent of the veterans and two per cent of the civilians were concerned about "Putting off marriage."

"Nervousness" was indicated by thirty per cent of the veterans and fourteen per cent of the civilians.

Marital Status (men)

Eight per cent of the single men mentioned 'drinking' as a problem. No married men mentioned it.

Seventeen per cent of the single men were troubled by 'trying to break off a bad habit,' while only one married man mentioned it.

Fifteen per cent of the married men were concerned about 'failing to go to church.' It was never mentioned by single men.

Married men (forty-one per cent) 'worry about examinations' to a greater degree than single men (twenty-four per cent).

'Doubting economic value of college degree' was mentioned by twelve per cent of the single men and three per cent of the married men.

Thirty-three per cent of the single men checked the problem 'not knowing what I want' while only ten per cent of the married men checked it.

In the categories 'adjustment to college' and 'finances and living conditions' the ratio of problems were proportionately even. Single men show greater concern in all other categories of problems.

FACULTY REACTION

The findings from this problem questionnaire were presented to the faculty where it provided considerable discussion. Many suggestions were made for improving the orientation of new students, extra-curricular activities, classroom instruction, guidance services, faculty counseling, etc. Some expressed concern that the college might accept responsibility for too many of the problems.

Copies of the students' check lists were requested by the deans of men and women for further analysis of problems. Many staff members asked for samples of student copies for study. Most of the students expressed the feeling that the experience of answering the questionnaire was worth while if anything was ever done about it.

Since this was a group study and the copies were unsigned by students it was impossible to identify cases urgently in need of help. However certain problems occurred so often that they seemed to lend themselves to a group approach. A survey and analysis of the most prevalent problems was made by those responsible for planning the freshmen orientation program and by the advisors of student organizations. The curriculum committee were in accord that the college could meet many of its responsibilities more adequately by revising the curriculum in two different directions: building a program of general education to meet the particular local needs and improving the personnel services.

It is impossible to state exactly the results this study had on college procedure except that it was one factor in making the faculty think more in terms of student problems and needs in building the new curriculum. It seems safe to state that the faculty are more conscious of the nature and range of student problems as they appear to students.

IMPROVEMENT IN SCORES ON THE AMERICAN COUNCIL PSYCHOLOGICAL EXAMINATION FROM FRESHMAN TO SENIOR YEAR

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INTRODUCTION

Among relatively unselected samples of the population, several investigators, Miles and Miles,[8] Conrad and Jones,[1] and Miles,[9] found little or no change in intelligence test performance of groups from the age of eighteen through the early twenties. However, various writers have reported a change in test performance of college samples from the freshman to the senior year. Hartson[3] gave equivalent forms of the Ohio State University Psychological Examination to four hundred three seniors from two Oberlin College classes three years after their first test. As freshmen the students earned a mean right answer score of 73, and as seniors a significantly higher score of 84. The greatest improvement was found among those who originally scored low in the class. Students who majored in the Mathematics-Science division were found to have been most skillful in numerical computations as freshmen and those who majored in the Language-Literature groups showed greatest initial ability in handling verbal relationships. There was considerable improvement in linguisitic test performance during the three college years regardless of the major; however, in general the students who did not major in Mathematics, Biology, or the Physical Sciences showed a loss in one of the two numerical computations tests, i.e., Arithmetic. Hartson concluded that such growth in intelligence as is measured by the vocabulary tests may continue for some years beyond college matriculation.

Rogers[10] administered one form of the Thorndike Intelligence Examination to the freshman students at Bryn Mawr College and a different form of this examination to some of these students who volunteered to be reexamined during a subsequent year in college. Her report is based on the fifty-six seniors, thirty-five juniors, and fifty-five sophomores who were retested. A mean gross gain of 2.6 points occurred after one year, a gain of 4 points after two years, and one of 5.36 points after a three-year interval.

Large and significant gains occurred in tests of Language Completion and Reading Ability, irrespective of courses pursued. On the test of Mathematical Ability, however, the Mathematics majors showed an increase in score of 5.4 points, the students who were not Mathematics majors but had taken some college mathematics showed a gain of 1.8 points, while students who had had no college mathematics lost 5.4 points on the average. Rogers observed that the power to handle the kind of tasks presented by the Thorndike Examination is greater in the senior than in other years because the abilities involved have had a chance to operate in acadenic work.

In the studies of Hunter[4] and Livesay[5] the same form of the American Council on Education Psychological Examination was used in the original testing and in the retesting. Hunter in 1940 gave the 1936 edition to the seniors, the 1937 edition to the juniors, and the 1938 edition to the sophomores at Converse College. The members of each class had been previously tested at the beginning of their freshman year. The percentile gains of the two hundred seventy-six women students averaged from 23 to 31 points for the three groups. In general, students who scored lowest on the first test made the most improvement on the retest. Livesay retested fifty University of Hawaii students at the end of their senior year with the 1931 edition of the A.C.E. The senior mean of 199.5 was significantly larger than the previous freshman mean of 154.7. The largest gains were made by the students who on their first test scored in the second or third quartile.

Several investigators compared the scores made on different editions of the A.C.E. by college students during their freshman and senior years. McConnell[7] gave the 1927 edition of this examination to seventy members of a Cornell College class when freshmen and the 1928 edition to this group as seniors. After the 1927 scores had been transmuted into the 1928 equivalents, the freshman mean was found to be 144.78, and the senior mean 185.2. Those who scored in the lower half of the original distribution made an average gain of 6 points more than those who scored in the upper half of that distribution. Four factors which, according to McConnell, may have been responsible for the increase in score were: growth in intelligence at the college level, growth in effective use of endowment, specific training, and less emotional tension.

Flory[2] tested a Lawrence College freshman class with the 1934 edition of the A.C.E. and retested seventy-four of the students in their senior year. Twenty of the students were retested with the original form and the others with one of three different forms. The results were made comparable by transmuting all scores into the equivalent 1934 percentiles. A mean gain in percentile rank of 8.6 points was found to be indicative of a real improvement in intellectual ability during the college years. When the students were grouped according to their choice of major and certain major fields were combined, the author found that the Social Sciences group ranked below the Fine Arts, the Language Arts, and the Science majors, both as freshmen and as seniors. However, no relationship was discovered between the amount of intellectual gain and the field of major concentration.

Sister Florence Louise,[6] using different forms of the A.C.E., tested two hundred eighty-eight students of three classes at Marygrove College when they were freshmen and forty months later when they were seniors. The freshman mean percentile ranks were 47, 48, and 51, respectively, while the senior mean percentiles were 75, 75, and 77. All of the gains were significant. When the students were grouped according to their major subjects, i.e., Fine Arts, Social Science, Science, and Language, all groups were found to have made comparatively large gains in both Q- and L-scores. However, students specializing in Science made the highest percentage of improvement in the Q-score, while those majoring in the Language Arts made the greatest gain in the L-score. The author concluded that improvement in intellectual abilities continues during the college years provided appropriate stimulation and constant training in thinking and in the application of knowledge are provided.

PROCEDURE

During the first week of October, 1944, the entire freshman class of Randolph-Macon Woman's College consisting of one hundred ninety-nine students was given the 1944 edition of the American Council on Education Psychological Examination. The test was administered simultaneously to all the students in three large lecture-rooms by members of the Psychology Department. Directions as given in the Confidential Manual were followed precisely and the answer sheets were subsequently

scored by departmental assistants. Students were kept in ignorance of their scores.

Three years later the present senior class was given the 1947 edition of this test. While the taking of the test the second time was optional, all but five members of the senior class who were tested in 1944 took the examination in 1947. The coöperation of the class had been requested by the dean of the College at a class meeting. A few days before the scheduled time of testing the following letter was sent from the dean's office to each senior:

> To the Seniors:
>
> The psychology test will be given on Thursday, October 16 at 7:00 p.m. in the Chemistry Lecture Room, number 60, Science Building. I appreciate your willingness, as expressed at the class meeting, to coöperate in this test. I hope you all will be there promptly at 7:00 so that you will not be delayed in completing it.*

There were one hundred thirty-seven seniors in the class of 1948. This number included, in addition to the one hundred thirteen subjects tested as freshmen in 1944, twenty-one transferring students and three students who entered Randolph-Macon in 1943 or in 1945. One hundred eight of the one hundred thirteen seniors who were tested in 1944 were retested in 1947, and it is with these one hundred eight members that this paper is principally concerned. The examination was administered the second time by the senior author and the answer sheets were scored by the junior authors.

The one hundred eight freshmen ranged in age from 16.6 years to 18.9 years at the time of testing. The mean age was 17.8 with a standard deviation of 0.42. The majority of them, i.e., seventy-three per cent, were from the Southern and Southwestern States. Eighty-one per cent had been previously educated in public schools.

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* The seniors who voluntarily reported to take the A.C.E. again after three years were without doubt willing to take the test and requested a report of their scores at a later date. However the senior author who has given many of the A.C.E. to freshmen observed in the seniors more uninhibited carefree behavior and a frequent tendency to be amused. They gave the appearance of being less well motivated than freshmen S's.

RESULTS

In Table 1 are presented the mean scores and the percentile ranks of the means of the students tested by the A.C.E. in 1944 and in 1947. It will be observed that in both testings the L-per-

TABLE 1.—MEAN SCORES AND PERCENTILE RANKS OF THE 108 STUDENTS TESTED BY THE A.C.E. IN 1944 AND IN 1947

	1944			1947		
	Scores		Percentile Ranks[1]	Scores		Percentile Ranks[2]
	Range	Mean		Range	Mean	
Q	29–65	47.5	72.7	31–68	50.0	87.4
L	33–144	78.9	76.2	49–114	81.4	89.0
Gross	81–160	126.2	78.0	82–165	131.9	89.0

[1] Based on the 1944 national norms for college freshmen.[11]

[2] Based on the 1946 national norms for college freshmen. In pre-standardizing the 1947 edition the Thurstones found the percentiles of the 1947 and the 1946 editions to differ so slightly that they recommend the use of the 1946 norms until the final norms for the 1947 edition are published. [personal communication]

centiles were slightly higher than the Q's, the difference being greater in 1944 than in 1947. The mean gross score of the one hundred eight freshmen was 126.2, which placed the class mean at the Thurstones' 78th percentile. This score is but slightly

TABLE 2.—SIGNIFICANCE OF DIFFERENCES BETWEEN 1944 AND 1947 MEAN PERCENTILE RANKS

	Higher Pr	Difference	$\gamma_{D \text{ per cent}}$	t	P
Q	1947	14.7	5.29	2.78	.01
L	1947	12.8	5.10	2.51	.02
Gross	1947	11.0	5.00	2.20	.05

above the mean of 125.15 obtained by the total freshman class which entered the College in 1944. After three years in college the mean percentile rank was increased by 14.7, 12.8, and 11 points on the Q-, L-, and total test, respectively. From Table 2 it will be seen that the Q-increase is significant at the one per cent

level, the L- at the two per cent, and the gross increase is significant at the five per cent level of confidence.

In order to determine whether or not the choice of major subject was related to either the 1944 or the 1947 test scores, an

TABLE 3.—MEAN SCORES AND PERCENTILE RANKS OF STUDENTS MAJORING IN ENGLISH, MATHEMATICS AND CHEMISTRY, AND THE SOCIAL SCIENCES TESTED BY THE A.C.E. IN 1944 AND IN 1947

	1944			1947	
	N	Mean Scores	Percentile Ranks	Mean Scores	Percentile Ranks
			Q		
English	28	47.2	71.6	50.2	82.2
Math. and Chem.	20	51.0	82.9	54.5	90.2
Soc. Sci.	35	45.9	66.9	48.8	78.7
			L		
English	28	80.5	79.0	86.5	91.7
Math. and Chem.	20	76.8	72.4	80.0	84.2
Soc. Sci.	35	81.1	79.9	80.2	84.5
			Gross		
English	28	128.5	80.5	136.2	91.0
Math. and Chem.	20	128.3	80.0	136.1	91.0
Soc. Sci.	35	126.4	78.0	130.3	87.0

attempt was made to separate the S's according to their fields of concentration. Although a Randolph-Macon student has a choice of majoring in one of nineteen departments, more than three-fourths of our seniors were majoring in seven fields: English, Mathematics, Chemistry, History, Psychology, Political Science, and Sociology. In Table 3 the mean scores and per-

centile ranks of the eighty-three students majoring in these seven departments are given after the Mathematics and Chemistry majors were combined and, similarly, after the Social Science majors were consolidated. The English and the Social Science groups are presumed to have had some special training in linguistic material, while the Chemistry and Mathematics majors have had some additional training in numerical or quantitative material. There were no Physics majors among the senior S's.

The mean gross scores of S's majoring in English and in Mathematics and Chemistry were practically identical in both editions, while those of the Social Science group were but 2 and 6 points lower, respectively. The corresponding percentile ranks of the Social Science majors were 2 points below the English and the Mathematics-Chemistry majors in 1944, and 4 points below them in 1947. However, as was anticipated, the students who subsequently majored in Mathematics or Chemistry were, respectively, 11.3 and 16 Q-percentile points above the other two groups on the 1944 edition. Similarly in 1947 the Q-mean percentile rank of the Mathematics-Chemistry majors was 8 and 11.5 points above the respective ranks of the English and Social Science majors.

On the L-division, the Mathematics-Chemistry S's achieved a mean percentile rank of from 6.6 to 7.5 points below the ranks of the other two groups in 1944. Three years later the L-mean percentile ranks of the Mathematics-Chemistry and the Social Science majors were practically identical and more than 7 points below that earned by the English majors. The highest mean percentile rank on L-, i.e., 91.7, was made by seniors who were English majors, and the highest mean percentile rank on Q-, i.e., 90.2, was made by seniors who were Mathematics-Chemistry majors. None of the 1944–1947 differences given in Table 3 were significant at the five or even at the ten per cent level of confidence.

The group of one hundred eight students was divided into quartiles based upon the 1944 gross scores. In Table 4 are presented the mean gross scores and the mean percentile ranks of the four groups in 1944 and the corresponding scores and percentiles achieved in 1947. Proceeding from the highest to the lowest quartile we find an increase of 2, 7, 14, and 24 percentile points, respectively, in 1947 over 1944. The corresponding t's of 0.43, 0.91, 1.20, and 1.84 progressively increase from the first to the

fourth quartile although none are significant at the five per cent level of confidence. The relatively greater improvement of low-scoring freshmen in their senior year has been reported by other investigators.

TABLE 4.—MEAN GROSS SCORES AND PERCENTILE RANKS OF STUDENTS TESTED IN 1944 AND 1947 AND SEPARATED INTO QUARTILES ON BASIS OF 1944 SCORES

Quartiles	1944			1947	
	N	Mean Scores	Percentile Ranks	Mean Scores	Percentile Ranks
Highest	27	148.8	96	150.9	98
Second	27	132.2	85	137.5	92
Third	27	119.4	68	125.1	82
Lowest	27	104.5	45	115.4	69

SUMMARY AND CONCLUSIONS

1) One hundred eight students were tested by the A.C.E. in the beginning of their freshman year at Randolph-Macon Woman's College and again in the early part of their senior year. The 1944 and 1947 editions were used, respectively.

2) In 1944 the mean percentile ranks were 72.7, 76.2, and 78.0, respectively, on the Q-, L-, and total-test when compared with the national norms for college freshmen of both sexes. In 1947 these percentiles were correspondingly 87.4, 89.0, and 89.0. All of the increases are significant at the one, two, and five per cent levels of confidence in the several instances.

3) Eighty-three of the students were placed in one of three categories according to their choices of major subject. The Social Science majors in 1944 and the English majors in 1947 obtained the highest mean percentile rankings in the linguistic division, whereas the Mathematics-Chemistry majors achieved the highest mean percentile rankings in the quantitative division both in 1944 and in 1947. Although all of the groups in all three comparisons achieved higher mean percentile rankings in 1947 than in 1944, none of the increases were found to be significant.

4) In conclusion, our findings, as opposed to those of a number of other investigators, show: (a) a slightly greater increase from the freshman to the senior year on Q- than on L- for the group as a whole, and (b) a smaller percentage of improvement in Q- by the Mathematics-Chemistry majors than on the part of the non-Science majors. In agreement with other writers on the subject we find: (a) a relatively greater improvement of score and percentile rank among the lower than among the higher scoring students, (b) a slightly lower ranking of the Social Science majors as compared with the other groups, and (c) evidence that lends support to the view that mental growth continues during the college years. The evidence suggests that college training stimulates mental growth such as is measured by the A.C.E. However, it is possible that bright or superior high-school graduates, as was the majority of the subjects tested in the various experiments, who do not attend college may show a similar increase in mental growth from eighteen to twenty-one years.

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RÔLE-PLAYING AS AN INSTRUCTIONAL AID

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Emphasis has been placed on 'education for life' by educators as a basic goal in education. Concern in developing the individual child rather than drill on subject content leaves the educator seeking pedagogical devices that will contribute to the attainment of this aim. It is thus the purpose of this paper to report an exploratory investigation into the use of a technique that has been advocated as a means of developing emotional and social maturity. So far as the present writer has been able to ascertain there have been no experimental studies as to the efficacy of rôle-playing in teaching.

Rôle-playing has been recommended by Hendry,[3] Zandry and Lippitt,[12] Shoob,[10] and Kay[6] as an effective teaching device. According to Lippitt and Zandry, this technique blends in with " . . . a much needed educational trend in classroom practice towards: (a) using actual group experiences as a functional basis for teaching; (b) paying more attention to interpersonal relationships of classmates in grouping procedures for selecting participants in learning situations; (c) developing techniques for creating the appropriate 'group social and emotional atmosphere' for effective learning; (d) recognizing the need to teach skills and attitudes rather than items of knowledge."

It is believed that in the course of a rôle-playing situation individuals actually learn new ways of responding, and develop an understanding and feeling for other personalities. This is assumed to facilitate the growth of social and emotional maturity.

Rôle-playing or reality practice is described by Lippitt[7] as "the playing or rehearsing of rôles that the student encounters in others or must play himself in his every day life." Thus the rôle-playing director (teacher) sets up a situation in the classroom and various students are asked to play characteristic rôles in this staged situation. As they play the parts, each participant tends to identify himself with his rôle, and reacts as if in an actual situ-

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[1] The writer wishes to thank Dr. John E. Horrocks for his coöperation in carrying out this study at the Ohio State University.

ation. Insight is afforded into his own rôle as well as the rôles of others.

For example, a boy having difficulty with his father may be asked to play the rôle of a father; another boy plays the rôle of the son, creating a father-son problem situation which is acted out. In responding in this 'play' situation, the son may begin to understand for the first time the father's rôle in their relationship.

Members of the class not playing one of the rôles participate as an active audience, and later criticize the performance. The director acts as a catalyst urging the participants into more intense personal interaction. He suggests courses of action until the behavior of the actors tends to be spontaneous. The audience as well as the cast are encouraged to immerse themselves in the drama. A critical discussion follows the performance.[1]

Since there seems to be no experimental evidence to support allegations as to the effectiveness of this technique, the present study was devised to investigate experimentally the contribution of rôle-playing technique to the individual's social development and to his understanding the behavior of others.

Due to several factors, which will be brought out later, the results of this investigation are inconclusive. However, a brief report of this pilot study is given here in order to illustrate suggestions made below that may be of help in further investigations dealing with similar problems and obstacles to those encountered in this study.

DESCRIPTION OF THE STUDY

Educational psychology at the Ohio State University (second course in psychology) has a prevailing educational philosophy consonant with the 'education for life' approach.

The specific goals have been stated[4,9] to be:

1) The acquisition of psychological facts helpful for teachers.

2) The development of ability to apply psychological principles in life situations as in teaching.

3) Making more acquaintances as evidence of increased social facility.

4) Development of a socialized approach to meeting problem situations.

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[1] For a more detailed discussion, the reader is referred to Zandry and Lippitt,[12] and Moreno.[8]

To test the hypothesis that rôle-playing added to the effectiveness of this type of learning by the students in educational psychology at the Ohio State University, the following experimental design was employed: Two educational psychology classes taught by the same instructor were used. One class numbered twenty-nine and the other included thirty-four students. All students were enrolled in the College of Education, the majority being sophomores. It was considered desirable to equate the groups for (1) academic year level, (2) sociability as measured by the socio-metric device described below, (3) academic grade average, (4) ratio of male and female, and (5) ratio of Negro students. Rôle-playing sessions were held in Class A, meeting at 8 A.M. Class B, meeting at 9 A.M., did not have any rôle-playing sessions. Except for the rôle-playing sessions, both classes were taught by approximately the same methods—essentially class and group discussions.

Only three rôle-playing sessions were held during the quarter. The first dealt with the problem of handling a behavior problem in the sixth grade. One student acted as the teacher and another as the problem child. Several others participated as additional members of the class. The second session attacked the problem of gaining acceptance for a handicapped child among his classmates. The third involved a teacher being reprimanded by the principal within hearing distance of some children.

Measuring Devices.—As measures of achievement in the course, the following instruments were used: (1) an objective test, and (2) a social distance scale.

The objective test, used to determine partially the grade in the course, consisted of ninety-six objective items selected to measure what the student learned in the course. Its coefficient of reliability has been estimated in several unpublished studies to be from .75 to .90 using split halves, uncorrected for length. The test was constructed by several instructors, experienced in teaching the course, as a means of measuring achievement of the objectives.

The second instrument used, the Ohio Social Acceptance Scale, is a product of the Bureau of Educational Research at the Ohio State University. No estimates of reliability or validity are available. The test was specifically designed by Louis Raths and his co-workers to measure social acceptance, which is one of

the principal objectives listed above. The instructions call for the student to rate everyone in the class on a five-point scale with each category clearly defined. Names are listed on a separate sheet.

Each of the two measures was given at the beginning and also at the end of the course.

TABLE 1.—SCORES OF BOTH GROUPS ON OBJECTIVE TEST GIVEN AT BEGINNING AND END OF QUARTER

	Beginning Test		Terminal Test	
	Group A	Group B	Group A	Group B
92–89			2	1
88–85		2	3	3
84–81	1	3	5	9
80–77	8	4	10	10
76–73	1	9	2	9
72–69	8	5	3	
68–65	3	5	3	1
64–61	2	4	1	
60–57	3	1		
56–53				
52–49				
48–45				
44–41				
40–37				
36–33	1			
	N = 27	N = 33	N = 29	N = 33
	M = 69.76	M = 72.68	M = 76.59	M = 77.73
	σ = 2.40	σ = 1.78	σ = 1.77	σ = 1.12

Results.—Table 1 compares the two groups at the beginning of the course and at the end on the basis of the objective test. Fluctuations in *N* throughout the study are the result of absences. These represent a possible source of bias in the data. No appraisal is available as to the effect of these absences upon the results.

Initial significant difference between the two groups computed by Fisher's *t* is 4.18 with Group B the higher. This is significant

at the one per cent level of confidence. At the end of the term, the *t* is 3.17 with Group B still the higher. This is also significant at the one per cent level of confidence.

This would seem to indicate no relative change between two heterogeneous groups following exposure to two different teaching

TABLE 2.—SCORES OF BOTH GROUPS ON SOCIAL DISTANCE SCALE GIVEN AT BEGINNING AND END OF QUARTER

	Beginning Test		Terminal Test	
	Group A	Group B	Group A	Group B
53–51			1	1
50–48			2	2
47–45			2	1
44–42			1	4
41–39			1	1
38–36			2	4
35–33			2	4
32–30			2	5
29–27	2		4	3
26–24	1		4	3
23–21	2		3	2
20–18	2		1	
17–15	3	5		
14–12	9	9		1
11– 9	8	4		
8– 6		8		
5– 3		5		
	N = 27	N = 31	N = 27	N = 31
	M = 15.11	M = 10.78	M = 32.78	M = 34.39
	σ = 1.82	σ = 1.55	σ = 3.08	σ = 3.02

approaches. In both the initial and terminal application of the test, we are unable to reject a null hypothesis that there is no significant difference between the groups not accounted for by chance. Therefore, the results here are inconclusive.

Table 2 gives the results for the Social Distance Scale, also given at the beginning and end of the term. The *t* at the begin-

ning is 8.92 with Group A on top. The *t* for the terminal test is 1.97 with Group B now higher. With fifty-six degrees of freedom, the terminal difference is nearly significant at the five per cent level of confidence, as the obtained difference may be expected to occur by chance seven times in one hundred.

Here, we are able to reject the null hypothesis at the five per cent level of confidence for the terminal testing, but we can not reject the null hypothesis for the initial testing. We might also note the reversal in top groups. Our conclusion is, then, that we have achieved homogeneous groups following an experimental period initiated with heterogeneous groups. A significant change has occurred, but the inadequacy of our experimental controls prevents determination of the operative variable or variables.

Comparison of mean grade for the two groups indicated in Table 3 reveals a *t* of 1.5. With degrees of freedom equal to 50, this difference may be expected to occur by chance fourteen times in one hundred.

The two classes were originally equated for ratio of each sex and ratio of Negro students. Exact proportions are reported in Table 3.

DISCUSSION OF RESULTS

1) The results are inconclusive, and no interpretation can be made since the necessary conditions of an appropriate experimental design were not met. The two groups were not successfully equated originally for factors such as (1) sociability (extent of acquaintances), (2) academic average, or (3) psychological information. It is impossible to account for whatever changes occurred, since it can not be demonstrated that either of these instruments can evaluate heterogeneous groups when given heterogeneous treatment as in this study.

2) No attempt was made to solicit the opinions of the members of the class toward rôle-playing. This might have been done to obtain introspective data regarding the efficacy of this technique.

3) Studies are needed to determine in what courses rôle-playing might be useful, e.g., courses in mental hygiene, educational survey, educational methods, child psychology, and clinical psychology at the college level. Studies are also needed to determine the skills or extent of training the director must possess.

4) It is believed that more than three rôle-playing sessions are

needed in conjunction with measures of achievement to justify the rejection of rôle-playing as an effective teaching device.

TABLE 3.—COMPARISON OF POINT HOUR RATIO, SEX RATIO, NEGRO STUDENT RATIO, AND ELEMENTARY PSYCHOLOGY GRADES

	Grade	Average	Elem. Psych. Grade	
	8:00	9:00	8:00	9:00
3.2–3.1	5	1	A 1	2
3.0–2.9	3	1		
2.8–2.7	2	1	B 7	6
2.6–2.5	5	8		
2.4–2.3	5	6	C 13	19
2.2–2.1	3	4		
2.0–1.9		3	D 7	5
1.8–1.7		3		
1.6–1.5				
1.4–1.3		1		
1.2–1.1	1			
	N = 24	N = 28		
	M = 2.21	M = 2.30		
	σ = .49	σ = .43		
	Negro Ratio		8:00	9:00
			3 of 29	3 of 34
			8:00	9:00
	Sex Ratio		M 15	M 17
			F 14	F 17

5) Lessons learned from the present study prompt the following suggestions for future investigations:

(A) Prior arrangements must be made with administrative officials to insure that students obtained will compose comparable groups. The experimenter can not depend upon chance, as selective factors operate, such as: variation in class hour, certain groups need to take the course at a required hour, or 'cliques'

may schedule course together. If this is not feasible, equating may be accomplished within larger groups.

(B) Due to the asymptotic nature of the learning curve, it is possible that heterogeneous groups initially may become homogeneous in their terminal scores regardless of system of treatment. This is particularly applicable to the measuring devices used in this experiment.

(C) If the matched group method is used, these factors should be equated: academic average, grade record in previous courses in the same field, sociability, sex, and race.

(D) More adequate measures of emotional and social development must be used.

Some of these controls were used in the present study, but partial control does not permit the drawing of conclusions from this investigation.

SUMMARY

A rôle-playing technique was employed on three different occasions in a class in educational psychology. Failure to achieve control of all the necessary variables precluded obtaining experimental results leading to the formation of unequivocal conclusions.

Suggestions for improvement of further investigations were given, and allusions were made as to the appropriateness of this technique in furthering an 'education for life' approach.

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VOCABULARY AS AN INDEX OF LEARNING IN A SECOND LANGUAGE*

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STATEMENT OF THE SPECIFIC PROBLEM

Since there is widespread dispute as to the relative effectiveness of the various 'new' and 'old' methods of teaching foreign languages, there is a need for objective measures of progress in language learning. In evaluating methods of foreign language teaching previous studies in the teaching of language skills have indicated the importance of vocabulary size as a factor in both language aptitudes and language progress. Such vocabulary measurements have been shown experimentally to be not only accurate in themselves in giving a true picture of the number of words learned by an individual, but also as indices of the correlated development of other language skills. The problem of this study, therefore, is to provide a rational and an experimental measuring procedure by which it is possible to evaluate the various methods of teaching in the field of a second language; namely French, in quantitative terms.

OBJECTIVES OF THE STUDY

The specific purposes of this study are as follows:

1) To determine the possible significance of vocabulary development in the learning of a second language as a factor of major importance in itself.

2) To develop a method for determining the significance of vocabulary size as a possible index of the correlated development of other language skills.

3) To develop parallel forms of general recognition vocabulary tests for the French language: (a) to determine the total vocabulary based upon the largest dictionary available, and (b) to determine the number of words known in a frequency list of the 3,340 most commonly used words in the language.

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* This article is a summary of the author's unpublished doctoral dissertation, School of Education, Northwestern University, 1947.

SIGNIFICANCE OF THE PROBLEM

Vocabulary size, in the sense of knowing the single commonest meaning of a large number of words, has been shown by Seashore and Eckerson[1] to be closely correlated with intensive knowledge of additional or multiple meanings of words, the development of diction or the ability to make fine distinctions in the choice of closely related words, and to a variety of other language skills, including language usage, reading comprehension, general intelligence, and scholastic achievement in specific subject-matter fields.

In speaking of vocabulary as an index to the learning of a second language, it is evident that it is by no means an isolated measure of the number of words known, but also one of the best ways of estimating the extent of progress in related language skills for which objective measures may not yet have been developed for a specific language.

SUMMARY AND CONCLUSIONS

A basis has been provided by this study for the objective measurement of total vocabulary size in French as a second language learned by American English-speaking students. The specific measures consist of a series of French tests.

Two of the tests which have been developed, Dictionary Forms A and B, are equivalent multiple choice type samples of one hundred eighty-one words each, drawn from all the words in the most commonly used bilingual dictionary; namely, Heath's *French and English Dictionary*.[2] These tests are intended to determine the percentage of French words whose commonest single meaning can be recognized.

Dictionary Forms A and B were administered in their final form to two hundred subjects including the entire range of knowledge of French from a mixed group of psychology students, many of whom had no knowledge of French, to experts in the language. The arithmetic means (Form A: 52.43; Form B: 51.41) and standard deviations (Form A: 15.16; Form B: 14.11) of the two forms are sufficiently alike to make the tests equivalent. The items in each of the two forms have been arranged in order of increasing difficulty (defined in terms of the percentage of persons missing an item). This means that less experienced students in French need take only a portion of either test in

order to obtain an estimate of their total vocabulary. The Pearson coefficient of correlation of Forms A and B for the sample population in question was .90 and the Spearman-Brown prediction for the use of Forms A and B together is .95.

The words in Dictionary Forms A and B were systematically selected so as to be representative of the kinds and proportions of all words in the dictionary. It is fair to assume, therefore, that the percentage of words known on a given form is approximately the same as the percentage of words known in the entire dictionary of over 61,000 words. It is thus possible to estimate the total number of words known by a student in the French language. This estimate includes only basic words (for example, étudier) and does not take into account derived terms (for example, étudie). Dictionary Forms A and B give the student an opportunity to show his knowledge of a representative sample of all words in the French dictionary whose meanings he could recognize.

Since it is known that a relatively small number of words in any language account for a very large proportion of all words used in ordinary conversation or writing, it is also possible to sample a frequency list of the French language and from this to determine both the total number and percentage of words known from such a list—in this case the Tharp[3] frequency list of over 3,300 words. Frequency Forms K and L, developed from this list, should be particularly useful in measuring relative progress when all students are being taught French by the same methods of instruction, using the same textbooks and the same sources for vocabulary material. But it must be remembered that tests such as Frequency Forms K and L based upon the most frequent 3,340 words will not differentiate among persons who have been serious students of French for a considerable period.

Frequency Forms K and L were administered in their final form to two hundred and five subjects ranging from those with no knowledge of French to experts in the language. While standard deviations (Form K: 10.65; Form L: 9.55) and the means (Form K: 103.54; Form L: 91.25) were not sufficiently alike to make Forms K and L equivalent,* the differences in the

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* The two forms have since been equated by proportionate exchange of certain items between Form K and Form L according to differences in percentage of difficulty.

estimated total number of words known in the Tharp list were not great. The number of words known when estimated from the mean score of Form K were 2,071 and Form L, 1,825. The coefficient of correlation for the experimental sample is .90 and the Spearman-Brown prediction when the two forms are used as one is .95.

In order to assure the representativeness of such vocabulary tests as a way to measure various methods of language teaching, and to enable other investigators to reproduce these methods of measurement, a procedure for the construction of the tests has been systematically described. This includes the conventional studies of item analysis, central tendencies, variability, and reliability for each form so that persons wishing to use the tests in measuring the effectiveness of various types of teaching may compare their findings with those of the original groups. In addition, a series of parallel measures of objective tests have been outlined which could be constructed to measure other aspects of language development, such as comprehension, diction, and pronunciation. Eventually it should be possible for teachers of the French language to use such a battery of tests as criteria for the effectiveness of any given method of teaching and, in view of the objectivity and the representativeness of the materials sampled, to provide a fair and meaningful way of evaluating the related strengths and weaknesses of various methods.

More specifically, the educational uses of the vocabulary tests developed in this study include the following:

1) *Dictionary Forms A and B:*

a) These vocabulary tests furnish a way of estimating the total French recognition vocabulary which is fairly independent of the particular textbooks or other sources used in classroom or other work.

b) They furnish a more objective method of comparing various methods of teaching in one aspect of language development; namely, vocabulary size.

c) They can furnish an inventory of a student's present attainment in the language or serve as a basis for planning further instruction, if desired.

d) The tests may be used to measure a very wide range of vocabulary knowledge, since they are designed for all levels of French study.

2) *Frequency Forms K and L:*

a) These vocabulary tests offer a means of measuring the most frequently used portions of French vocabulary for certain groups of beginning students.

SUGGESTIONS FOR FURTHER RESEARCH

1) In the light of the relationships found between French vocabulary size and English verbal skills, it would be valuable to determine the correlation between English and French vocabulary sizes where the amount of training in French is held constant.

2) As the tests are used to measure progress of students in beginning and more advanced classes, it may be possible to build up norms for different types of courses in order to estimate the extent of achievement of individuals or groups enjoying any particular method of teaching a second language.

3) In order to obtain a more complete picture of the learning of related skills, it will eventually be necessary to develop parallel objective tests dealing with representative samples of pronunciation, diction, comprehension, and so on, as outlined in the projected psychograph of major language skills.

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BOOK REVIEWS

J. C. FLANAGAN, Editor. *The Aviation Psychology Program in the Army Air Forces.* AAF Aviation Psychology Program Research Reports, No. 1. Washington: Government Printing Office, 1948, pp. 316.

Most of the work of psychologists during the war took the form of skillful application of previously-established principles. Even the wartime research projects rarely attacked frontier problems. The two major exceptions, and therefore the most significant for psychologists generally, are the program of the OSS described in *Assessment of Men* (Rinehart, 1948) and that of the Army Air Forces, reports of which are emerging in a series not yet completed. Flanagan, in Volume I, has provided an introduction, summary, and interpretation of the entire Air Force project. The AAF program provided a unique opportunity for the application and development of personal techniques. Because psychologists of vision directed the program, problems were studied imaginatively; the latest methods were given a thorough trial, often on vast numbers of cases, and a large number of new ideas were conceived and tried.

The AAF and OSS projects are in interesting contrast. The OSS implemented the most advanced clinical methods and had some success in predicting performance on the basis of a personality diagnosis. The AAF group tried the last word in psychometric and statistical method; they had great success in predicting from abilities, but almost none in using personality data (p. 265). Perhaps that is a reflection of the impotence of present psychometric approaches to personality.

Flanagan has provided a satisfying one-volume survey of the work in aviation psychology. Fifty pages are devoted to a history of the program—pages which the reader looking for ideas will probably begrudge. But this section once past, the reader embarks on a veritable merry-go-round of ideas and useful data. The breathless quality of Flanagan's book, which sometimes leaves a major idea after only the briefest presentation, is understandable, since his volume is but the 'show window' telling what nineteen other volumes have to offer. Topics of these volumes range from "Research Problems and Techniques" to "Psychological Program in AAF Convalescent Hospitals" and include

four volumes on classification and testing, six on training, and others on motion-picture testing, and equipment design.

Flanagan's is no perfunctory and formal summary. Instead, he writes as a psychologist appraising the program. He does not hesitate to give his professional judgment on the significance and implications of the studies of his co-workers. The result is stimulating and challenging, and has implications for everyone using psychological tests, training men, or doing research in applied psychology.

A great advantage in the hands of the AAF investigators was the large numbers of cases available, and the possibility of repeating studies on successive classes. From the work, we learn that multiple regression weights vary widely from sample to sample; that negative weights are suspect and usually vanish; and that combination of separate tests which have low 'validity coefficients' can yield a highly valid estimate of probable success in learning a complex skill. Such findings must be considered in any future processing or prediction. Certainly the fact that as many as twenty tests were needed to select for only three standardized air-crew jobs is a devastating reflection on the assiduity of peacetime studies of aptitude. The schools can scarcely take pride in the thoroughness of programs for educational and vocational guidance based on only one or two general tests. The improvement of civilian predictions will, however, be harder than in the Air Force, where duties are highly uniform. Another of the findings crucial for education is that various highly responsible activities had quite different aptitude requirements (pp. 244–5). Academic aptitudes were by no means the key to the good pilot. Men who failed in one gunnery job proved excellent on another.

Flanagan's comment on the aptitude test intercorrelations is striking: "The principal point gained from studying these intercorrelations is not so much the hypothesis for explaining the small amounts of common variance as it is the obviously large amount of unique variance in each of the tests in the battery" (p. 244). This is in direct contradiction to the impression given by Guilford in Volume III of the series. Guilford made a factor analysis of the AAF tests, and has stated repeatedly that suitable tests of the common factors isolated would be the best basis for attacking all prediction problems. On the contrary, the number of practically useful aptitudes is apparently almost limitless. Flanagan

(p. 241) speaks of "fifty, or one hundred, or even more" important independent traits. Considering that twenty-seven common and dozens of unique factors were found just in the limited sphere of human performance involved in air-crew skills, even this seems an underestimate.

Of the hundreds of topics discussed, Flanagan stresses most the idea of job analysis. He considers determining the 'critical requirements' of tasks a significant way to improve school curricula, ratings of success, and selection (pp. 251–253, 272–276). The critical requirements of a job are those aptitudes, traits, and skills that make the difference between success and failure. In the AAF, follow-up studies of graduates identified causes of mission failure, which in turn implied the ways in which training had been inadequate. From these studies, together with conventional 'judgment of experts' procedures, Flanagan considers that the nature of air-crew jobs was well understood. He then takes off into a strong recommendation that all education should be reconsidered in terms of "a comprehensive, scientific analysis of the critical requirements of working and living in our modern civilization."

While Flanagan's proposals are not explicit and not discussed in detail, it appears that he urges a Charters-type analysis of adult activities (commercial, civic, cultural, vocational, and avocational). If a factor can be found which separates the successful from the unsuccessful, this would become an objective of education. This proposal seems to the reviewer to be unsound, although it may be developed in Flanagan's mind better than in his book. Aside from the specific goals of vocational training, success is indefinable, and probably an inappropriate concept. Is the school to turn out successful trout fishermen? Is being cultured something one 'does successfully'? Are the critical requirements of civic success the same for everyone—or is the intelligent voter as successful in his way as is, in a different way, the political leader? Second, one can question the philosophical basis of the proposal. Flanagan, it seems, would equip citizens for life as it is lived, rather than as it should be lived. If there are values which our present culture does not reward, should the schools abandon those values? And, in looking at success, may not education overlook happiness as a goal? The third difficulty is practical. Will methods useful in investigating

a specific skill, such as piloting, be useful when applied to life as a whole? May not the 'critical requirements' of business success be in part the opposite of the requirements of avocational success—and if so, what does the school do? Can we train for thrift and enterprise, suspended judgment and decisiveness, perfectionism and adaptability—all at once? Certainly Flanagan's proposal deserves consideration and a fuller exposition, but the present statement suggests that he has a dangerous plan in mind.

It is rare that the interpretations in the volume go beyond data as in this instance. More often, the data are left without drawing their full implications. A few of the findings educators must ponder for themselves are these: Tachistoscopic training of perception had no apparent value (p. 178). Morale in combat appears not to be related to understanding 'What we were fighting for,' according to reports of returnees (p. 250). Films have their greatest advantage over other methods in teaching dynamic relations—changing events or co-variation (p. 187). Time in training courses is often wasted because of inadequate practice, delays between practice and use of skill, or inadequate variation of training content (pp. 166, 169).

So brief a sampling of ideas does not reflect fully how much the Air Force discovered about men and how they learn. The volume, and the series it represents, can surely be recommended to serious students of educational psychology. The only adverse comment one can suggest is that packing so much material into one volume tempts the reader to overlook some ideas which merit more amplification.

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L. A. PENNINGTON AND IRWIN A. BERG, Editors. *An Introduction to Clinical Psychology.* New York: Ronald Press Company, 1948, pp. 595. $5.00.

The increasing interest in clinical psychology and the increasing demand for professional training in this field which have been accelerated following World War II, present a pressing need for more and better textbook material. The volume being reviewed is presented "to describe eclectically at the introductory level what clinical psychologists do." In the preface the editors point out that this text is intended for use in colleges at the junior level. It is necessary to neglect here the question whether

clinical specialization should be in the undergraduate curriculum at all, and to evaluate this book in terms of the purpose set forth.

The twenty-two chapters, which are the work of twenty-three different authors (incidentally, there are no chapters by either of the editors), vary a great deal in quality. Fifteen chapters can be rated as average or better, in terms of their content and the adequacy with which they satisfy the stated purpose. The remaining seven chapters are open to serious criticism. The twelve chapters which rate highest are those by Cattell on the meaning of clinical psychology, Mowrer on the concept of abnormal behavior, Marzolf on the physically handicapped, Ball on psychosexual behavior, Kuhlen on later maturity, Horrocks on achievement and aptitude testing, Magaret on intelligence tests, Sargent on projective methods, and the chapters on treatment procedures by McKinney, Snyder, Johnson, and Yacorzynski.

Three additional chapters are acceptable, but they do not reach the level of the twelve just mentioned. Dysinger's chapter, "Signs of personality disintegration," and that by Anderson, "Behavior problems of children," may be criticized as being much too elementary and not giving clear-cut statement of their topic. The Dorcus chapter on "Psychoses and psychoneuroses," may be criticized as being a pedantic following of traditional psychiatric disease classification, although as such it is a good summary.

Negative criticism in a review is always difficult because to condemn arbitrarily is unfair, while to justify the condemnation is too expensive of space. The seven chapters which appear to me to be inadequate may be allowed all too brief comments. When Sherman in writing on the mental defective says "a person with an IQ below 70 is considered mentally defective" and "the diagnosis of hereditary mental deficiency is usually made by eliminating other specific causes . . . " one can only reject the chapter as misleading to the student. Bear in writing on the educationally backward, does an adequate job on reading difficulties, but summarily dismisses all other subject disability problems, and completely neglects the general problems of retardation. Sanford's chapter on speech and personality is an excellent review, and was a valuable article when published in the *Psychological Bulletin*, but it is both too advanced and too specialized to have a place in this volume. The chapter by Washburne on tension states, and Cleckley on anti-social person-

alities, are both marked by confused thinking, lack of organization, and vagueness in presenting the problems they are intended to discuss. Neither would be very useful for the student. Donahue's chapter on interest and personality tests devotes half of the space to a general discussion of interests without clinical orientation, and her treatment of personality tests is catalog in style, without serious consideration of clinical use. Finally, a chapter on psychiatry and clinical psychology by Dr. Wright, a psychiatrist, is best characterized by his statement "he [the psychiatrist] is assisted by the psychologist in the resolution of diagnostic problems, in the administration of specific forms of therapy, and in research."

Proper evaluation of a collection of papers must give attention to the adequacy of the editing. In a textbook intended for use by undergraduates as an introduction to a specialized field, one expects the editors to integrate the contributions so that there is logical development, without destroying the values of different treatments. The failure to do this is a serious lack in this text. The subjects included are all important, but the editors have allowed too extreme variation in level of writing. There is surprisingly little duplication among the chapters, except in the three dealing with test methods, in each of which problems of validity and reliability are discussed in essentially the same manner. There appear to be two serious omissions. In the third part on clinical methods, the four chapters deal only with measuring instruments and nowhere is there a discussion of interviewing techniques, the case history method, or the problems of diagnosis as such. Part 5, entitled "Professional Relationships," consists of only one chapter, already referred to, on the relations of clinical psychology and psychiatry. Nothing at all is said about the equally important relations with such professions as teaching, social work, or industrial personnel—to mention only three very obvious ones.

Unfortunately, in the general nature of things, negative criticism takes more space than commendation, so that this review may appear to be chiefly negative. This, however, is not the intention of the reviewer. Actually the book is a valuable contribution to the elementary literature of clinical psychology, and could be read with profit by teachers, administrators, and other professional people interested in problems of human behavior.

It is to be hoped that a revision of the work will correct some of the more glaring deficiencies.

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Henry Pratt Fairchild. *Race and Nationality as Factors in American Life.* New York: The Ronald Press Co., 1947, pp. 216.

"Many writers recognize the fundamental distinction between race and culture, and yet there is a striking dearth of explicit interpretations of this distinction in language easily comprehensible to the layman." This volume is chiefly for the educated layman, although passages of it might have been written with a professional audience in mind—particularly those setting forth a somewhat critical analysis of work of Boas and Benedict and Weltfish, as in the chapter "Anti-racism."

The distinctions between race and nationality are kept before the reader. The implications of these distinctions for our handling of various social problems, such as immigration and minority groups, are ably treated.

The treatment of nationality starts with the assumption that "strong, well-knit, harmonious nations are a good thing for humanity . . . " The treatment of social assimilation is interesting and stimulating: (1) assimilation of immigrants is largely a one-way process; it is the immigrant, not the host that is altered. (2) "The colonist and the immigrant are functionally two quite different types of persons." (3) Assimilation is not so much an intellectual transmutation as a spiritual, emotional, and social one. The meaning of nationality is emphasized in a chapter "The Jews," which is quite a superior chapter. The meaning of race is emphasized in a chapter "The Negroes."

The author does not, it seems, give sufficient weight to cultural factors in race prejudice. He appears to eliminate them by definition. To be sure race is a biological matter; but, according to the reviewers' lights, attitudes toward this biological phenomenon need not be biologically determined at all.

The book is realistic in tone. It clearly distinguishes between what seem to be facts and what we might wish the facts to be. It is impatient of some of the pronouncements of 'liberalism.' It aims not so much to reform as to inform. One of the results of the book, whether intended or not, may be to make us more

tolerant of intolerance. The book certainly should have the effect also of reducing intolerance.

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SHERMAN TINKELMAN. *Difficulty Prediction of Test Items.* Contribution to Education No. 941. New York: Bureau of Publications, Teachers College, Columbia University, 1947, pp. 55.

This report is concerned with an investigation of the degree to which item difficulty can be predicted prior to actual test administration. Thirty examiners were asked to estimate the percentage of candidates likely to answer correctly each of the items in a hundred-item multiple-choice test. A sample of one thousand test papers was then analyzed. Validity of the predictions was determined by comparing predicted difficulty with actual difficulty.

Validity of the estimated difficulty varied from judge to judge. The pooled judgments improved the level of prediction considerably. There was a tendency to overestimate the percentage of candidates passing difficult items and to underestimate the percentage passing easy items. The judges predicted equally well in nine specific item content areas. There was greater agreement among judges in estimating relative difficulty of easy than of difficult items. The chief weakness of subjective estimation of item difficulty seems to be in possible constant errors. Little confidence can be placed in estimates of absolute item difficulty. But since judges are probably able to estimate relative item difficulty accurately, the use of subjective item difficulty estimates appears to offer a positive contribution.

This study was well designed and the data adequately analyzed. The results will be of value to those who need to know something about item difficulty prior to giving a test.

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